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THE GLENEYRIE FORMATION AND ITS BEARING ON THE AGE OF THE FOUNTAIN FORMATION IN THE MANITOU REGION, COLORADO

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The Paleozoic section to the east of Pike's Peak, Colorado, in the Manitou region is composed of four members, as follows: (1) a basal Cambrian sandstone; (2) a limestone series, the lower half of which is Ordovician (the age of the upper half is still in doubt); (3) a fossil-bearing sandstone of Pennsylvanian age; and (4) the Fountain formation, arkose sandstones, grits and conglomerates, the lower members of which are almost certainly of Pennsylvanian age, while the upper members may in the end be definitely correlated with the Permian and Triassic. The purpose of the writer in the present paper is to describe the sandstone member, (3) in the series as given above. It has not previously been described. It contains the only identifiable plant remains of Pennsylvanian age which have been found thus far in the Rocky Mountain region. These fossils make possible its safe correlation with the Upper Carboniferous of the East. The Fountain beds appearing in the section next above cannot, therefore, be older than the Pennsylvanian, and the occurrence in them of brachiopods which have been recently found points to their being of Pennsylvanian age.

Our knowledge of the Paleozoic section in the Manitou region warrants us in making the following statement with a large measure of confidence as to its correctness. Overlying the basal granite, which with its included schist and gneiss represents the Archean and Algonkian, there are found 50 feet of upper Cambrian sandstones. The lowest member of the Cambrian is an 11-foot band of white, fine-grained quartz feldspar sandstone. The succeeding layers going upward are stained by iron a deep red-brown, and they show irregular green markings due to the presence of glauconite. It is the upper Cambrian which is represented. The amount of lime increases as one goes up in the series, until after 50 feet have been passed a gradual transition brings in thinly bedded limestones of Ordovician age, known as the Manitou formation. The line of demarkation between the Cambrian and the Ordovician in Manitou or Williams Canyon may be drawn at the "Narrows" just below the 18-inch band of hard, red, porous limestone which contains *Dalmanella testudinaria.* The beds up to this point are lithologically similar to the sandstones and limestones at the base of the section to the north along Deadman's Creek described by W. T. Lee,[1] and the correlation is justified by a comparison of the brachiopod faunas of the two regions. Near Canyon City, Colo., where cherty layers of the Manitou limestone rest directly on the granite, the Cambrian is wanting.

Above the Cambrian in the Manitou or Williams Canyon section 266 feet of limestones (including the Ordovician or Manitou limestones) were measured. A marked unconformity appears at the top of the series. The limestones at the base of the Ordovician are thinly bedded. Higher up the single layers are each one or more feet in thickness. Many of them carry chert inclusions. The prevailing colors are gray, bluish gray, and buff. A few layers near the top show deep red. The limestones are rarely free from magnesia, but a heavy band near the top is nearly pure lime carbonate.

The Silurian and Devonian are not known in the section, nor anywhere along the Front Range in Colorado. The Harding sandstone and the Fremont limestone of Ordovician age, so well represented near Canyon City, are not found in the Manitou region. To the north along Glen Eyrie Creek, three miles from Manitou, the limestone series is 311 feet thick.[2] Here Carboniferous fossils have been obtained from the upper beds by Dr. A. W. Grabau. It seems probable that at this point the equivalent of the Millsap, as suggested by Dr. G. H. Girty, is present, although the rock is not lithologically similar to the Millsap of the type locality in Garden Park, described by Dr. Whitman Cross. In the Manitou Canyon section there is no sign of an unconformity to mark Silurian and Devonian time until the top is reached. Fossils of Ordovician age occur at many points in the lower 118 feet, but the upper 148 feet are not fossiliferous. It may well be that the Millsap has no equivalent in the section at this point.

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[1] *American Geologist*, Vol. XXIX (1902), p. 96.

[2] See reference to Peale's section in *Professional Paper 16*, U. S. Geological Survey, p. 153.

Resting on the limestone, and separated from it by an erosional unconformity, are 40 feet of gray and buff, finely laminated sandstones, made up almost entirely of quartz grains, with thin bands of black shale near the bottom of the series. This formation is below the unconformity at the base of the Fountain. Typical exposures are met along the stream-bed in Quarry Canyon, a mile to the northeast of Manitou, where the upper contact with the Fountain is exposed. The basal contact with the highest brecciated limestones of the Manitou Canyon section may be seen on the right hand just at the entrance to Manitou Canyon. Small fragments of the limestone occur in the lowest beds of the sandstone, which rest on an uneven limestone floor. Southward from this point the formation is covered by overlap of the Fountain. It may be traced northward as far as Glen Eyrie Creek, where it is well exposed, although the Fountain comes down to the basal granite a short distance beyond, to the north. The sandstone formation in question is therefore of no great thickness, and its outcrop, an eighth of a mile or less in width and but three miles long, is of small extent. It possesses considerable interest, however, because of the fossil plants which are found in the shaly layers irregularly distributed through it. A collection of these fossils was made and forwarded to Dr. David White, of the United States Geological Survey. *Lepidodendron obovatum* and *Lepidodendron aculeatum* were identified by him. Dr. White has pointed out to the writer that these species indicate a horizon equivalent to the Pottsville of Pennsylvania. These plant remains are the only ones of Pennsylvanian age recorded up to the present time from the Rocky Mountain region. The shales which contain them are bands four feet and less in thickness, black from contained carbonaceous matter and traces of coal. They occur near the base of the formation, are at times lens-shaped, and quickly thin away. They indicate swamp conditions near the level of the sea. Lepidodendron markings have also been found in the sandstones. Concretionary markings are common in certain layers. The formation has not up to the present time received a name. It is proposed to call it the Gleneyrie formation, making use of the name of the locality in which the best exposures are met. The Gleneyrie sandstone is a strong rock to resist weathering, and the weaker overlying Fountain grits have been stripped back down the dip for some distance from their outcropping edge.

The Fountain formation next above in the series, resting on the Gleneyrie sandstone and separated from it by an unconformity with overlap, has a thickness of over a thousand feet. The formation is made up of arkose sandstones, grits and conglomerates, red, vermilion, maroon, and occasionally white. Dr. Whitman Cross, who first used the name in the Pike's Peak folio, assigned the Fountain beds to the Carboniferous. It is clear that in the Manitou region, since they overlie the Gleneyrie sandstone, they are not earlier than the Pennsylvanian. Fossils from the Fountain are extremely rare, and only two genera, brachiopods, have been found in the Manitou region. They occur 200 feet above the base of the formation in a three-foot layer of red, fine-grained, shaly sandstone. Good exposures are met above the stone house in Quarry Canyon. Here shells of Orbiculoidea are not hard to find. Dr. G. H. Girty has kindly examined the specimens and referred them tentatively to *Orbiculoidea manhattanensis*. With them a single productoid shell, resembling *Marginifera ingrata*, has been collected, but the specimen is not sufficiently good for accurate determination. *Orbiculoidea Manhattanensis* has a wider range than the Carboniferous, but its occurrence at this horizon points strongly to the Pennsylvanian age of the Fountain beds near Manitou. The "Saurian" limestone conglomerate of Triassic age, so well developed in the San Juan Mountains of southwestern Colorado, is not known along the Front Range. For the final proofs as to whether any of the upper layers of the Fountain are to be referred to the Permian or to the Triassic we must await the results of such studies as Dr. Williston has been conducting in the Canyon City field.